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Toward a sustainable energy future in Turkey: An environmental perspective

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A B S T R A C T

As long as the energy future of Turkey is concerned there is a consensus among all parties involved in the subject that a strong sustainability based on diverse range of renewable and variety of sources with efficient and fair use of energy is a must. The main criterion in this approach is to use energy with the least possible greenhouse gases and other harmful emissions. A shift in focus to meeting the needs of energy service sector will be immediately felt in the sustainable energy future in Turkey. Another important aspect of the sustainable energy future of Turkey is that all energy users, as more knowledgeable and active participants will be more involved in various stages of the process. However, Turkey has a long way to reach this vision, because of growing greenhouse emissions related to energy production and utilization of alternative energy is slow. Besides, the intensity of energy of the Turkish economy is decreasing slower than many other OECD countries. In addition, energy consumption per person in Turkey is far above the service needs, even for modern lifestyles. There are substantial obstacles on the way to a sustainable energy future of Turkey, such as various aspects of economic structure, a misdirected energy market process, and a lack of vision among the decision makers.

Contents

1. Introduction

Energy is one of the main elements for both economic and social development and for quality of life in all countries as well as

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Turkey [1,2]. However, the current situation in production and consuming much of the world′s energy is not that much promising as far as sustainability is concerned if technology for producing and consuming energy remains more or less same and overall quantities do not change substantially [4]. It would not be a speculation to claim that the need to control greenhouse and other harmful gases and substances will increase [5,6]. It is also clear that this control can be achieved through utilization of more efficient methods in energy production, transportation, distribution and consumption. Infrastructures for electric supply in many developing countries around the world are constantly increasing as decision makers and investors are recognizing pivotal role of electricity in improving quality in sustainable economic growth. However, compromise in sustainable development if a balance between economic, environmental and social outcomes is not achieved with proper measures is a growing concern [1–7].

In this paper, three specific issues those are important for the sustainable development of Turkey are analyzed. These three issues are potential consequences of climate change, technological developments for reducing air pollution and taking various measures for sustainable use of natural resources. Indicators to determine the current state and measure progress in each specific area are presented. An evaluation of potential problems as well as an assessment of government policies in those three areas is provided. Institutional organizations are also discussed whether they are appropriate to be able to integrate policies across various elements of sustainable development. An overview on renewable resources and sustainable development in Turkey is also provided.

2. Methodology

This section presents the methodology for the energy indicators for sustainable development, grouped according to the social, economic and environmental dimensions. The units specified for the indicators in each of the methodology sheets represent, in most cases, recommended units based on data availability and should facilitate international analysis. Individual countries may decide to use different units based on national practices and the specific objectives sought in using this analytical tool. It is recommended that all economic data used to develop the energy indicators for sustainable development should be in terms of constant prices. These data may be in national currencies. Table 1 presents the list of indicators and each weights for Turkey [8].

Table 1
Weights of indicators for Turkey.

Pillars	**Percent (%)**
Environmental dimension	
Production of reusable waste	6.43
Production of toxic waste	6.16
Environmental conditions	5.74
Education for environmental issues	5.65
Waste recycling, collection, treatment and reuse	6.34
Energy generation versus energy demand indicates	6.72
Environmental dimension total weight	**37.34**
Economic dimension	
Energy generation and energy demand	6.42
Projected demand	6.56
Investment capacity	6.36
Control of environmental liability	6.23
Environmental protection expenditure	6.32
Economic growth	6.10
Local economy basis	6.34
Economic dimension total weight	**44.33**
Social dimension	
Program to encourage the conscientious use of energy	6.12
Household income per capita	6.09
Existence of technical training schools	6.12
Social dimension total weight	**18.33**
Total	**100.00**

2.1. Social dimension

It is estimated that about one-third of the world′s population, depend mainly on traditional biomass sources of energy; 1.5 billion are without electricity. About 250 million people have been connected to electricity grids or have been provided with modern biomass or other forms of commercial energy options since 2000 [9–11]. However, in the absence of adequate measures, the number of people with no access to commercial energy will remain stable or continue to grow as demographic growth outpaces electrification in some parts of the world. Therefore, a sustainable development goal is to increase the accessibility and affordability of energy services for the lower-income groups of the population in developing countries so as to alleviate poverty and promote social and economic development [9].

(a) *Underlying definitions and concepts*: Consumption of traditional fuels refers to the non-commercial consumption of fuelwood, charcoal, bagasse, and animal and vegetable wastes. Total household energy use might comprise commercial energy.
(b) *Measuring methods:* This indicator is defined by the share of households without access to commercial energy and by the share of households for which dependence on non-commercial fuel exceeds 65% of total energy use.
(c) *Limitations of the indicators:* Availability of data on the number of households without access to commercial energy or electricity may be a limitation. Heavy dependence on non-commercial energy, defined as 70% dependence on traditional energy, is an arbitrary benchmark for this indicator [9,12].
(d) *Alternative indicators:* An alternative indicator may be useful is ‘Per capita consumption of non-commercial or traditional energy’. However, this does not really capture the essence of the issue.

2.2. Economic dimension

(a) *Purpose:* This dimension measures the level of energy use on a per capita basis and reflects the energy-use patterns and aggregate energy intensity of a society [9].
(b) *Relevance to sustainable development:* Energy is a key factor in economic development and in providing vital services that improve quality of life. Although energy is a key requirement for economic progress, its production, use and byproducts have resulted in major pressures on the environment, both by depleting resources and by creating pollution [9–12].
(c) *International conventions and agreements:* Currently, there are no conventions or agreements that specifically refer to the regulation and/or limitation of energy use per capita. However, calls have been made for the prudent and rational utilization of natural resources, improved energy efficiency and a switch to cleaner forms of energy. The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol call for limitations on total greenhouse gas (GHG) emissions, which result mainly from the combustion of fossil fuels [9].
(d) *Linkages to other indicators:* This indicator is closely linked with other economic indicators, such as energy use per unit of gross domestic product (GDP), energy prices, energy intensities and energy net imports; with environmental indicators such as GHG emissions, air quality and waste generation; and

with social indicators such as household energy use for each income group [11,12].

2.3. Environmental dimension

(a) *Purpose:* This indicator measures the total, the per capita and the per unit of GDP emissions of the three main GHGs from energy production and use that have a direct impact on climate change.
(b) *Relevance to sustainable development:* During the 20th century, the Earth′s average surface temperature rose by around 0.6 °C, and evidence is growing that most of this warming is attributable to increasing concentrations of GHGs in the atmosphere [9]. The amount of CO_2, for example, has increased by more than 30% since preindustrial times and is currently increasing at an unprecedented rate of about 0.4% per year, mainly due to the combustion of fossil fuels and deforestation. The concentrations of CH_4 and N_2O are increasing as well due to energy, agricultural, industrial and other activities [9–11].
(c) *International conventions and agreements:* The United Nations Framework Convention on Climate Change (UNFCCC) entered into force in March 1994. The Convention included a commitment by Parties, both developed countries and economies in transition (Annex I Parties), to aim to return emissions of CO_2 and other GHGs not controlled by the Montreal Protocol to their 1990 levels by 2000, although relatively few Parties actually met this goal. The Kyoto Protocol was adopted in December 1997.
(d) *International recommended standards:* The Kyoto Protocol sets targets for each Annex I Party with a view to reducing these Parties′ overall emissions of the six main GHGs by at least 5% below 1990 levels in the commitment period 2008–2012 [9–12].
(e) *Linkages to other indicators:* This indicator is closely linked to many other economic and environmental indicators, including energy use per capita and per unit of GDP, primary and final energy use and electricity generation, fuel mix, atmospheric emissions, etc.

3. The challenges

An extrapolation of the world′s history would foresee the prospects for the development of civilization that would include major catastrophes caused by hunger and poverty, by the destruction of the natural foundations of life and/or by man-made destabilization of the earth′s climate. All these challenges are all directly or indirectly related to the energy supply systems due to the following reasons [12–16]:

- Reducing hunger and poverty and even controlling the global population increase would require providing an increasing amount of energy services.
- Energy systems are responsible for about three-quarters of anthropogenic emissions of CO_2.
- Energy system consumes a significant portion of fossil resources and is the #1 source of air pollution.
- A functioning energy infrastructure and competitive energy prices are necessity for economic productivity of developed countries. Energy issues featured prominently in the discussions of all earth summits and in the conferences on Environment and Development in Rio de Janeiro in 1992 and the World Summit on Sustainable Development in Johannesburg in 2002 organized by the United Nations [12,13].

Despite these challenges related to energy issues, there is a well-accepted consensus in society. But the degree of consensus dwindles when it comes to specific targets to be achieved and the models to be adopted. Controversial and sometimes contradictory opinions take place among influential groups in society, usually not on the goals to be achieved but on the means to be used. Availability of energy is of central importance for every society, because of the impact on human welfare, economic and social development and alleviating the living standards [12,13]. Global average energy consumption increases by approximately 2% a year on per capita. However it exhibits significant variations among the nations; there is huge difference in energy consumption per capita in industrialized and developing countries. A little over one billion people in the developed countries consume nearly 60% of the total energy supply and about five billion people in the developing countries consume the rest of total energy supply. Almost one third of the world population has a little or no access to affordable commercial energy [10–14]. The global commercial energy consumption is less than the one thousandth of the energy flow from the sun to the earth. Unfortunately, primary energy use is still relied on the fossil fuels, that is 80% of the total consumption. 7% of the global energy consumption is supplied by nuclear power, and 2% by hydropower and renewable energy sources. Traditional energy sources, such as firewood and coal are still the dominant energy form for developing countries which account for approximately 10% of the global energy consumption [3].

Impacts of energy consumption on environment have a long history. Deforestation caused by wood burning for centuries is being still felt on the local and global environment. Just during the last century, the world population increased more than three times while the fossil fuel consumption increased twenty times [9]. As a result of this dramatic increase, impacts of energy consumption on environment have grown from local to global. Immediate consequences of the energy consumption on the environment at local, regional and global level constitutes significant portion of human impact on environment. Massive amount of material flow, large scale infrastructures for every phases of energy production are involved in energy provision [9–12].

Hydropower plants have impacts on environment as well [17]. Some of them are positive effects, like creating milder climate, and some of them are negative effect, like causing flooding [14]. Nuclear plants creates extremely dangerous wastes [15]. One of the great challenges, the future civilization face is drastic climate changes caused by greenhouse gases emission created by fossil fuel burning [16]. There is a consensus among all parties concerning environmental issues that the way the energy is produced and consumed is not sustainable if the technology remains same and if overall quantities increase substantially [14–17]. Table 2 shows the world primary energy demand.

4. The concept of sustainable development

“Sustainable Development” is defined by Brundtland Commission, and the Rio Declarations with two seemingly contradictory

Table 2
World primary energy demand (Mtoe).
Source: Ref. [15].

Energy sources	1980	2010	2030
Coal	1,785	3,354	4,441
Oil	3,107	4,366	5,575
Gas	1,237	2,686	3,869
Nuclear	186	775	861
Hydropower	148	280	408
Biomass and waste	765	1,283	1,645
Other renewables	33	99	296
Total	7,261	12,842	17,095

concepts: consuming natural resources sparingly and continuous economic development [14]. According to the Brundtland Commission sustainable development in a "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs". Even though the Brundtland Commission′s definition has arisen against a background of environment and poverty, it represents an ethically motivated claim which is derived from considerations of fairness with future generations in mind [14]. In general terms, sustainable development takes into account equity within and across countries as well as across generations, and incorporates economic development, the conservation of the environment and the natural foundation of life and social welfare [15,16]. Successful policies for sustainable developments should be able to address those three dimensions in a balanced way with taking into account their interaction and making trade-offs whenever necessary. Energy is directly related to the three dimensions of sustainable development. Although the understanding of sustainability is well accepted it does not address how to assess sustainability; for example with no or little reference to the energy provision [14–16].

The necessity of limiting ecological burdens and climate change can definitely be substantiated within the framework of defining sustainability in concrete terms. However, it becomes harder when it is confronted with the question of whether the finite feature of energy resources is compatible with the concept of "sustainable development", because all energy sources which are consumed today will not be available for the future generations at a certain point in time. One natural consequence of this situation is that the renewable energy form is compatible with sustainable development [13–16]. However, this conclusion has two drawbacks: First, all renewable energies depend on non-energy related resources and materials that are scarce in supply. Second, it would mean that non-renewable resources may not be used at all in the future. In general terms, the second law of thermodynamics dictates that the use of non-renewable resources is inevitable [15–18].

Deposits of energy and raw materials that distribute in the earth′s crust cannot make any contribution towards securing the quality of life if they cannot be found or extracted because of the absence of the necessary exploration and extraction techniques or if they cannot be produced economically [9,11]. Therefore, state of the technology is the determining factor, that transforms raw resources into useful resources and plays an integral role in determining their quantity [13]. Compatibility of the use of limited stocks of energy with the concept of sustainability is possible if the future generations would have a fair amount of energy resources that are usable from a technical and economic viewpoint. It must be noted here that in the past the proven reserves, i.e. the energy quantities that are available technically and economically, have risen despite the increasing consumption of fossil fuels [14,15]. In addition, it was the technical and scientific progress that made new energy bases technically and economically viable, like nuclear energy and some of the renewable energy sources [15–18]. Environmental dimension of sustainability is primarily affected by environmental pollution, including the ones related to the today′s energy supply, are due to the anthropogenic flows of substances, substance dispersion that is the release of substances into the environment. It is therefore clear that it is not the energy itself to blame for the environmental pollution but the release of substances connected to the energy systems, such as the SO_2 or CO_2 released after the combustion of coal, oil and gas [12,13]. This situation is quite clear when it comes to solar energy which, with all working potential made available by it, is the principle source of all life on earth but it is also the greatest generator of entropy by all means, because almost all of the sun′s energy radiates back into space after it has been transformed to heat at the ambient temperature in one way or another. Since the solar energy is all radiation, it is not attached to any material carrier, and therefore the generation of entropy due to the solar energy does not produce any environmental pollution in the broader meaning of the word [12,13].

Economical consumption of energy and/or making all rare resources available is of particular significance in connection with the concept of "sustainable development" besides expanding the resources in various ways [13]. Since the provision of energy services requires the use of some scarce resources including non-energetic raw materials, capital, work and the environment, the efficient use of resources in connection with the supply of energy does also affect sectors other than energy as a resource [15,16]. However, it is a general economic principle to use all resources efficiently which can be derived from the concept of sustainability. It can be concluded from them that it is more efficient if fewer resources, including the resource environment, are utilized for an energy system or an energy conversion chain for the provision of energy services [15–18].

5. Sustainable development in Turkey

There is a growing concern in the long run that sustainable development may be subject to compromise if proper measures are not taken to maintain a balance between economic, environmental and social outcomes [3]. Three specific issues of sustainable development that are of particular importance for Turkey that are addressing climate change, reducing air pollution and ensuing sustainable use of natural resources are analyzed [1,4]. Indicators for each case are introduced to determine the current state, to measure progress and the evolution of potential problems. An assessment is also provided on government policies on this subject. It is also discussed in this section if the institutional arrangements are appropriate to integrate policy-making process across the different elements of sustainable development [1–6].

5.1. Elements of a sustainable energy vision for Turkey

Probably the most critical question for the sustainability of the energy future of Turkey is to estimate the bigger picture of this issue. It might be presumptuous from various points of views to put forward an energy vision for Turkey. Drawing a strong sustainability framework, in broad terms, should involve the following major elements [4,10,11]:

- The production and consumption of energy in Turkey will be undertaken in such a way that it should protect the critical capitals of natural resources. It is important to protect the natural capital both from intergenerational welfare perspectives and also from its intrinsic values. One important aspect of this protection is that emissions should be reduced to levels that can be processed by the environment. Especially the energy-related greenhouse gas (GHG) emissions should be substantially reduced below current levels by 60–80%.
- One of the *sine qua non* requirements of intergenerational equity is that the exploitation of non-renewable energy resources in Turkey should only occur at a rate equal to the creation of renewable substitutes. Besides, those exploitation rates of renewable energy resources are limited with their regeneration rates [18,21].

One way to ensure this objective is to shift from non- renewable energy resources to renewable alternatives to produce energy in Turkey. In addition to this requirement energy resources should be exploited at all levels of production and transformation as

efficiently as possible, and energy providers should focus on meeting Turkish citizen′s requirements for energy services in the most efficient manner possible rather than encouraging the consumers to consume more energy [18,20]. Table 3 shows total energy consumption in Turkey.

Importance of energy to economic development and wellbeing of Turkish Nation from an 'energy service needs' perspective will be recognized for a foreseeable future of sustainable energy [3]. Using a 'hierarchy of energy needs' approach, 'order of access to energy' can be regarded as the first step in energy service needs and it is therefore fundamental for the sustainable development of Turkey [8]. In determining the order of access to energy, two levels approach can be considered. The first and fundamental level is to meet the energy service needs of all Turkish citizens [4]. Therefore it should be ensured the availability of sufficient energy supplies. The second level of accessibility of energy consists of empowering Turkish people in connection to energy supply and use. As far as empowerment is concerned, Turkish citizens should be active participants of energy systems rather than just passive consumers to increase their understanding of energy systems [3,8,11].

Promoting production and use of energy intergenerational (social) equity is a must for a sustainable energy future in Turkey. This requirement includes encouraging affordable access to energy services by low income people and greater fairness in the local and global distribution of energy [8]. The broader terms of a sustainable energy future just described above are my own suggestions. They are consistent with the principles that are set out by a declaration entitled 'National Strategy for Ecologically Sustainable Development' on sustainability. This declaration was initially agreed between the Turkish Government and state and local governments in 1992 [19].

It should be noted that the most important aspects of this vision are shared by significant majority of Turkish citizens, as indicated by recent opinion polls. It should be noted another point about the sustainable energy framework outlined above is that it should not be rigidly applied, trade-offs between its various elements may be required from time to time. Thus, a sustainable energy pathway adopted by one group or community may be different from the one adopted by another group; even though both pathways can be considered within the strong sustainability framework [12–14].

5.2. Climate change

Turkey is one of the fastest growing countries whose household income is at level of the OECD countries [1–4]. This remarkable economic growth has been associated with a rapid growth of greenhouse gas emissions. However, carbon emission from Turkey does not contribute to the pressure on the global climate more than any other country. Therefore, reducing the burden on global resources at low cost and without jeopardizing the growth of the economy is a major issue the policy makers is facing [5]. Overall greenhouse gas emissions originated from fuel combustion jumped 65% in the 1990s, in contrast to more modest growth in the rest of the OECD countries. Although Turkey has been growing faster than the rest of the OECD countries, the relatively rapid growth in emissions cannot be directly related to economic growth [8]. The principal reason for the relatively higher increase in emissions is attributed both an increase in the use of energy per unit of output and an increase in GHG emissions per unit of energy supplied from renewable sources such as wood, animal waste, etc [15]. However, the statistics for the year of 2000 indicate that CO_2 emissions per unit of GDP were similar to the average among the OECD countries despite more rapid growth of economy-wide greenhouse gas emissions [13]. A number of features shared with some other OECD countries suggest that it is possible to achieve considerably moderate the growth of greenhouse gases emissions in Turkey with little or even no cost. Energy derived from carbon-intensive coal and lignite in Turkey has the largest portion among the OECD countries before the natural gas was an option as an energy source [3,13]. Power plants are the major source of most greenhouse gas emissions in Turkey. For a long time, power plants have been largely state-owned and operated under non-commercial criteria. Following a government decision to expand the industry in the late 1990s after a period of cutbacks in employment and output subsidies have been growing in energy sector in Turkey. A state-owned enterprise has been controlling the natural gas market, including import and export and makes all contracts related to natural gas. Since the government pays for certain imported gas whether it is used or not, the consumer prices are held low in order to encourage households to use more natural gas [18–20].

Table 3
Total energy consumption in Turkey (Thousand TEP).

Sectors	2004	2006	2008	2011
Household	20.952	23.677	28.323	29.650
Industry	28.789	30.996	26.906	30.830
Transport	13.775	14.994	15.996	16.765
Agriculture	3.314	3.610	5.174	5.374
Not Energy	2.174	4.163	3.244	4.890
Conversion sector	18.814	22.201	26.779	26.971
Total consumption	87.818	99.641	106.421	114.480

One of the consequences of privatization of the power plants will be the necessity of new pricing policies. At present, demand for electricity has increased by a high level of so-called "non-technical" system losses [5]. This phrase refers both to power consumed through illegal connections to the network and the bills that are not paid. The bottom line is that a significant proportion of power is consumed for free. In order end this practice, distribution companies will need to invest in new metering systems. Since illegal consumption can be up to 50% in some areas and since distributions companies may have different profiles of losses, this problem may be difficult to solve nation-wide. Enforcing power bills collections, though, would impact the de-coupling of carbon emissions form GDP growth. Besides, the overall price of electricity may have to rise to compensate the losses of the power industry and domestic and industrial tariffs will need to be re-balanced [9]. Currently, the government is searching necessary measures in the social area to complement the increasing electricity price due to liberalization [21]. In a free market economy though pricing policies should be separated from social support. Once this separation is realized, electricity prices can be determined by the rules of free economy which can be then used to achieve more efficient distribution of resources and the social instruments can achieve their goals. A new national policy on renewable energy is under development [13]. Development of new renewable sources for electricity production will be the principal focus. Regulations governing the new transmission companies should require them to give priority to the renewable energies for the connection of the power plants to the grid [16]. Moreover, retail licensees should be obliged to purchase power output produced by renewables with a price of the wholesale price of electricity or less and when an alternative supply is not available at a lower price [12]. This policy limits the extent of the subsidies to the renewable production to the costs of providing backup capacity for what is, often, an intermittent supply of electricity [10–12].

5.3. Greenhouse gas emissions

Greenhouse gas (GHG) emissions of Turkey has increased from 188 to 422 Million tons of oil equivalent (Mtoe) CO_2 equivalent

during the period 1990–2011 (see Table 4) and revealed an increase by 98% [22,23]. Fig. 1 shows GHG emissions per capita in Turkey. Fig. 2 also shows GHG emissions in Turkey. The highest share among greenhouse gases (GHGs) belongs to CO_2 with a share of 75–80%. In 1990 45 Mtoe CO_2 equivalent GHG emissions has been kept by sinks and this figure has increased to 98 Mtoe CO_2 equivalent in 2011. Countries of OECD and UNFCCC Turkey has the lowest amount of GHG emissions per capita, cumulative emissions and primary energy consumption per capita indicators [22,23]. Turkey's GHG emissions per capita was 5.6 Mtoe CO_2 equivalent for the year 2011 (see Fig. 1). GHG emissions per capita of OECD countries was approximately 15.0 t CO_2 equivalent, where GHG emissions per capita for EU-27 was 10.2 t CO_2 equivalent for the same year [22]. In 2009, 91% of CO_2 emissions were generated by energy sector where the rest 9% was caused by industrial installations, 59% of CH_4 emissions were caused by waste disposal and 30% was aroused from agricultural activities and finally, 74% of N_2O emissions were caused by agricultural activities. Especially for highly populated cities the share of CH_4 emissions has been decreased due to construction of waste disposal facilities. Besides, it's planned to have a sink capacity of 181.4 million tons carbon within first 20 years by the help of Afforestation Campaign Action Plan for 2008–2012 [19]. Turkey lays down the GHG emission policies as; a developing country has industrialization process in place, able to limit GHG emissions, targeting to enforce National Appropriate Reduction Actions and develop based on a carbon reduced development strategy. During the period between 1990–2011 GHG emissions caused by energy sector has increased from 132 to 302 Mtoe CO_2 equivalent (see Table 5). Taking a quick look on development of GHG emissions by sectors it's observed that the emissions increased constantly till 2011 excluding the year 2001 when the economic crises occurred [22,31]. Fig. 3 shows total GHG emissions by sectors in Turkey.

Table 4
Total GHG emissions (million tons CO_2 equivalent) in Turkey.

GHG emissions	1990	1995	2000	2005	2011
CO_2	141.58	174.09	225.61	259.77	344.69
CH_4	34.05	47.39	53.81	52.82	58.81
N_2O	12.22	16.82	17.14	14.67	12.65
F Gases	0.6	0.52	1.66	3.73	6.26
Total	188.43	238.82	298.21	330.98	422.42

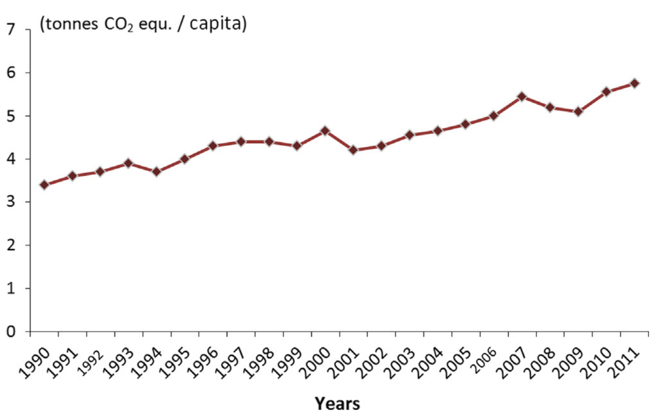


Fig. 1. Greenhouse gas (GHG) emissions per capita in Turkey.

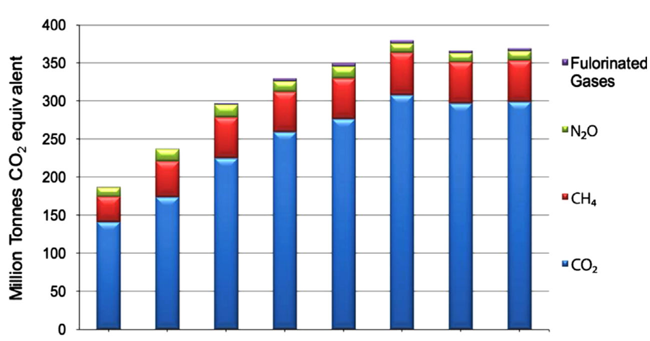


Fig. 2. Greenhouse gas (GHG) emissions in Turkey.

On the other hand, during the years 2008 and 2009 it's again observed that the emissions decreased possibly due to the global economic crises. Comparing sectors starting with 2005 the GHG emissions caused by agricultural activities and waste were stable and the increase in total emissions has caused by energy production and consumption and industrial processes. The biggest share in sectoral distribution of GHG emissions was belonging to energy sector with 75% in 2009. Emissions caused by consumed fuel in energy production, industry, transport and other sectors are considered within energy sector for the calculation above (see Table 5). Following the energy sector waste and industry has a share of 9% where agriculture sector has a share of 7% considering the emissions [19–21].

6. Barriers to a sustainable energy future in Turkey

Taking into account the recent trends in the world or by comparing with other OECD countries it is apparent from the discussions in the previous section that Turkey's sustainable energy performance does not stand up well to scrutiny. However it can be useful to examine the underlying factors to explain how they act as barriers to Turkey in moving to a sustainable energy future. Most of these barriers are discussed below [22–30].

6.1. Electricity market reforms

Following the trends in the rest of the world, power market in Turkey has undergone major reforms starting in the middle of 1990s. The aim of these reforms was to achieve competitive environment for power market, improve economic efficiency and thereby drive down electricity prices. Basic elements of this reform can be summarized as follows [22–30]:

(a) replacing monopolistic suppliers that are vertically integrated to the system by introduction of competitive marketing environment for retailers and producers,
(b) reforming former state-owned power plants to adjust themselves to commercialization and (in some cases) privatization, and
(c) establishing a National Electricity Market (NEM), supported by a grid in the populous eastern and southern with full integration to the system.

It would be a stretch to claim that energy market reforms have been successful even from a weak sustainability perspective. The focus of the reforms was to reduce short term electricity prices rather than to reduce long-term energy services costs from a diversity of sources, the regulatory framework imposed by the reform process created significant barriers to alternative energy sources. Energy efficiency and consumer oriented measures, for example, were not involved in the NEM, even though they are defined within a traditional welfare economics framework as ‘economically efficient’ in many cases. Demand management was excluded from the NEM because of the following reason [25,26].

Table 5
Million tons CO_2 emissions by sectors in Turkey.

	1990		1995		2000		2005		2011	
	$MtCO_2$, equivalent	%	$MtCO_2$, equivalent	%	$MtCO_2$, equivalent	%	$MtCO_2$, equivalent	%	$MtCO_2$, equivalent	%
TOTAL	187	100	238	100	297	100	330	100	423	100
Energy	132	71	161	68	213	72	242	73	302	75
Industrial Processes	15	8	24	10	24	8	29	9	56	9
Agriculture	30	16	29	12	27	9	26	8	29	7
Waste	10	5	24	10	33	11	34	10	36	9
Increase relative to 1990 (%)		–		27		59		76		126

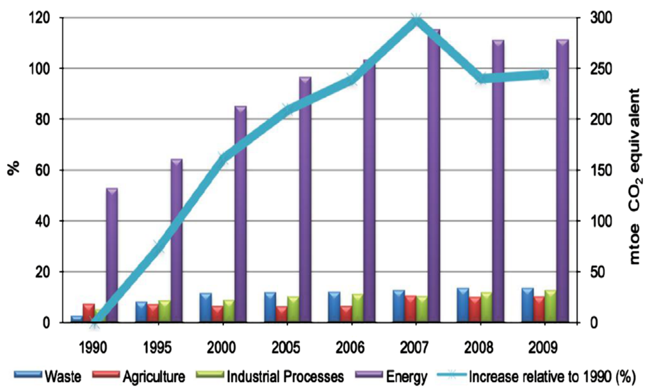


Fig. 3. Total greenhouse gas (GHG) emissions by sectors in Turkey.

(a) Main focus in NEM approach was on the supply side of the energy market with the wholesale market mechanism established to accommodate the needs of producers, poor regulations on the demand-side to response to bid into the market.
(b) Emphasis in the retail market is on sales-related revenue and it provides little financial incentive for retailers that makes demand management difficult.
(c) Retail consumer pricing policy is not cost oriented, especially for residential consumers who, generally, do not have time-of-use metering.

The energy market reform has other some additional flaws. First, consumer participation in energy markets has been obstructed in various ways. Direct discrimination against demand management and distributed production and indirectly through a general insufficient consumer informing and sometimes a complex regulatory framework are the most apparent ones. Second, it seems that there will be an adverse equity impacts created by the new market arrangements [30]. An immediate consequence of these arrangements is that large industry customers have used energy with lower prices compared to small- scale commercial and residential customers. Another consequence of retail consumer pricing policy that is not cost-reflective oriented, is that the households with high electricity consumption during peak hours are being subsidized by consumers with relatively low consumption [8,30,31].

The drawbacks pointed out above with the NEM were recognized in 2002 by the review panel that was established to measure the performance of the NEM and more recently by the Ministry of Energy And Natural Resources of the Turkish Republic. However, reviewing the actions agreed by the Ministry of Energy and Natural Resources, which consist largely of in-principle statements to examine the shortcomings further, it is clear that Turkish Government is not yet ready to embark on the fundamental changes required of the reform process to deliver sustainability focused on power markets in Turkey [31].

6.2. *The absence of visionary thinking*

For some reason, long term visionary thinking is not popular amongst the decision makers in Turkey, such as politicians, industry leaders, etc. Only decision makers with an eye to the longer term are able to put potential scenarios for the future in order to aid planning and risk management activities. Articulating a vision for the future leads the decision-makers to seeking to 'pick winners' or of 'social engineering'. Therefore, short-term financial and management planning cycles for the next election are preferred to vision or goal setting for future. Apparently, political leaders are hesitating to propose a vision that disturbs the comfort zone of the community [10,21].

For an independent observer it appears that the energy policy practices in Turkey are pretty 'relaxed'. Current energy strategies and policies, at both the national and local level disregard the current patterns of energy production and use in Turkey that could be unsustainable, or do so only in passing. There is not an articulated vision for a sustainable energy future either. Instead, ensuring the status quo is emphasized in these documents. The so-called *Blue Book* entitled "Securing Turkey's Energy Future" issued by Turkish Government in 2011, is a typical example on this point [24]. As pointed out earlier, the principal focus of the *Blue Book* is on the continuation of the accelerated development of Turkey's fossil fuel resources and on maintaining the cost of energy input low for export industries. There is no reference in the strategy described in the *Blue Book* for energy access issues [26]. Strategies for energy equity, energy security, and energy supply diversity are never mentioned in this report either. However, a considerable amount of attention is devoted for energy efficiency and it is also acknowledged that the overall energy efficiency in Turkey's has improved at less than half the rate of other OECD countries. However, initiatives in the strategy aimed at addressing this situation consist of the following principal elements [24–26]:

(a) An inquiry to examine the potential economic and environmental benefits of improving energy efficiency, and
(b) A statement of support in principle to reform the energy market to remove disincentives to energy efficiency.

The Mandatory Renewable Energy Target (MRET), which has been the main factor behind almost all renewable energy projects launched in the last decade, including the wind farms discussed in this article is perhaps the most successful renewable energy initiative established in Turkey. It was commenced in 2000 by the Turkish Government [23]. The aim of MRET is to increase the contribution of renewable energy to Turkey's power consumption by 9500 GW h/year by 2010 and maintain this requirement until 2010–2020. MRET was introduced in 1997 and one of its major goals was to increase the share of electricity produced from renewable sources to total electricity consumption to 12% by 2010, which was an increase of 2% on the 1997 share [24]. Because of unexpected strong growth in fossil fuel-based power generation

in the late 1990s and early 2000s however, the share of renewable electricity was realized around 8.3% in 2001. MRET is now expected to increase the share of electricity from renewable resources to 10.5% of total electricity in 2001, which corresponds to an increase of less than 0.5% on the 1997 share and only 2% above the 2001 share. Thus the share of renewable energy target achieved through MRET will be modest compared to the targets that are now targeted in other OECD countries [27–29].

Despite this poor progress, the Turkish Government has rejected the goal to increase the power generated from renewable sources to 20.000 GW h in 2020 recommended by MRET review panel (Table 6). As a consequence of this adverse step, investors are hesitating to support renewable energy projects. It is projected that the share of renewable energy in total electricity production will fall once again below 8% in 2020 because of the absence of major new initiatives (Fig. 4). Therefore, the renewable energy vision of Turkey is now a long way off [24,25].

7. Conclusions

The prospects of achieving energy sustainability in Turkey in a foreseeable future appear to be remote in the light of the discussion on the trends and barriers for sustainable energy, as discussed in the previous sections. There are however good reasons to be more optimistic for sustainable energy future. The support of Turkish citizens should be concrete action rather in-principle form for a sustainable energy future. It is only less than two percent of Turkish population that is slightly more than one hundred thousand Turkish households who are now members of 'green power' schemes. However this significantly low level of participation should be assessed by taking into account the fact that the participating households voluntarily pay a premium of up to 40% of their electricity bills. It should be noted that these households are joining to green power schemes with no or little support from markets and institutions. Even opposition of the local community to wind farms, as discussed in full detail in the introduction of this article, could contribute to a more sustainable energy future sooner or later, albeit in a circuitous manner. As pointed out before, the pathways adopted by different groups for sustainable energy future may display variations; even they fall within the strong sustainability framework. Large-scale wind farms are a typical example in this regard. Although wind power is a renewable energy source with zero GHG emissions and with minor environmental impacts overall, large-scale wind farms could be at odds with some of the strong sustainability principles. Although wind power can be envisioned as a significant factor playing a role in Turkey's sustainable energy future, it seems like it can be developed with the full support of local communities by embedding in the local distribution network, rather than as a large grid-connected system, since it is remotely located, relatively small-scale distributed source.

Table 6
Renewable energy production in Turkey.

	1998	2007	2009	2011
Wood	7.4	3.6	3.3	3.2
Animal & plant residues	2.0	1.0	1.1	1.0
Hydraulic	4.9	3.0	2.9	3.3
Geothermal	0.8	0.9	1.2	1.4
Solar	0.3	0.4	0.4	0.7
Total (Thousand TEP)	15.4	8.9	8.9	9.6

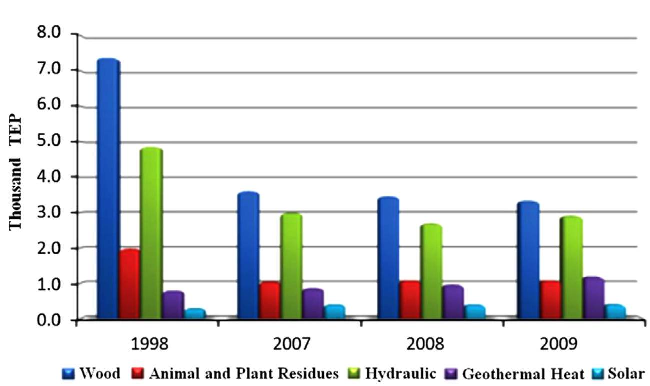


Fig. 4. Share of renewable energy in consumption for Turkey.

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